DOCUMENT RESUME

ED 468 396 SE 066 609

TITLE	State of Delaware Science Curriculum Framework Content Standards [and] Performance Indicators: Level One (Grade 9) [and] Level Two (Grade 10) [and] Level Three (Grade 11).
INSTITUTION	Delaware State Dept. of Education, Dover.
PUB DATE	2001-00-00
NOTE	35p.
AVAILABLE FROM	For full text: http://www.doe.state.de.us/DPIServices/Desk_Ref/DOE_DeskRef.htm.
PUB TYPE	Guides - Non-Classroom (055) -- Legal/Legislative/Regulatory Materials (090)
EDRS PRICE	EDRS Price MF01/PC02 Plus Postage.
DESCRIPTORS	High Schools; Inquiry; *Physical Sciences; *Science Curriculum; Science Education; Scientific Principles; *State Standards
IDENTIFIERS	Delaware; *Performance Indicators

ABSTRACT

This document, from "The Teacher's Desk Reference to Standards and Performance Indicators for Curriculum Planning and Unit Development," is part of the Delaware Department of Education's ongoing efforts to provide assistance and support to local school districts in their development of a standards-based curriculum. It explains the science curriculum framework content standards of the state of Delaware and provides performance indicators for grades 9-11. (YDS)

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State of Delaware Science Curriculum Framework Content Standards [and] Performance Indicators: Level One (Grade 9) [and] Level Two (Grade 10) [and] Level Three (Grade 11)

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STATE OF DELAWARE
Science Curriculum Framework
Content Standards

Standard #1 - Nature and Application of Science and Technology

Science as Inquiry

1.11 The identification and formulation of appropriate questions guide the design and breadth of a scientific investigation. Based on the type of questions(s) proposed, investigations explore new phenomena, solve science and technology related problems, compare different theories, resolve conflicts concerning societal issues, determine reasons for discrepancies in previous experimental results, or test the practicality of a consumer product.

1.12 Scientific investigations in many cases follow no fixed set of steps. However, there are certain features of a valid scientific investigation that are essential and result in evidence that can be used to construct explanations.

1.13 Tools and technologies extend human capabilities to perform investigations in more detail and with greater accuracy and
improved precision.

1.13 The close examination of evidence is necessary to construct logical scientific explanations and present arguments which
defend proposed explanations. Such critical analyses of supporting evidence are not only important to scientific investigations but help in judging the validity of claims made in advertisements or concluded from investigative reports.

1.15 Publication and presentation of scientific work with supporting evidence is part of the critique, review, and validation process conducted by the scientific community. The presentation of such work in accessible journals and reviews adds to the body of scientific knowledge and serves as background for subsequent investigations in similar areas.

Science, Technology, and Society

1.21 The practice of science and technology is not a linear process. In many cases, the desire of scientists to find what is real in nature creates opportunities for technology development. At the same time, technology provides scientists with tools and techniques that allow expansion of their capabilities and effectiveness.

1.22 The social, economic, and political forces of a society have a significant influence on what science and technology programs are pursued, invested in, and used.

History and Context of Science

1.31 Science is an international activity in which significant inventions and innovations have come from around the world. Even though scientists live and work in different cultures and come from different backgrounds, many of their activities are part of international collaborative efforts, and the knowledge created is shared in order to maximize the benefits to society.

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1.32 Science is divided into many disciplines such as astrophysics, biochemistry, and geophysics. Each discipline is a field of endeavor in itself and requires specialized training. Many of the tools, techniques, methods, and much of the knowledge created in one discipline are shared across disciplines in order to maximize the impact of the work.

Standard #2 - Materials and Their Properties

Properties and Structure of Matter

2.11 All matter is composed of minute particles called atoms. Atoms are electrically neutral and consist of a nucleus of neutrons and positively charged protons surrounded by negatively charged electrons. Most of the mass of an atom is concentrated in the nucleus, whereas, most of the space is occupied by the electron cloud. The electron structure of the atom strongly influences its chemical behavior.

2.12 Elements are pure substances that are composed of identical atoms. Chemists and physicists have identified the elements, isolated them from their natural sources, synthesized them from other elements, and determined their properties. The periodic table arranges the elements in order of their atomic numbers (the number of protons in the nucleus). The elements are grouped according to similar chemical and physical properties (metals, non-metals, noble gases). The periodic table is used to predict the behavior of the elements and relates variations in their properties to the electron configuration of their atoms.

2.13 Substances are formed by atoms interacting with one another and transferring or sharing electrons. These interactions generally involve the electrons farthest from the nucleus, and result in the formation of chemical bonds and molecules, the building blocks of compounds.

2.14 The properties of compounds depend on the properties and interactions of their molecules. These molecular properties and interactions depend on the kinds of atoms in the molecule, molecular shape and motion, and the electrical forces that exist between molecules. An enormous variety of biological, chemical, and physical phenomena can be explained by these properties and interactions. Bonding diagrams and three-dimensional models can be used to represent and visualize atoms, molecules, and their interactions.

2.15 Elements and compounds exist as solids, liquids, and gases. In solids, the atomic and molecular structure are orderly and nearly rigid and the vibration of atoms and molecules is constrained to a fixed site. In liquids, atoms and molecules move more freely and randomly, and this movement is insufficient to overcome the attractive forces that exist between the atoms and molecules. In gases, molecular motion is rapid and random and overcomes the attractive forces that exist between molecules.

2.16 Isotopes of a given element differ in the number of neutrons in the nucleus, although their chemical properties remain essentially the same. Radioactive isotopes spontaneously decay, releasing energy, and/or emitting particles. The products and energy resulting from radioactive decay have uses in research, industry, and medicine. If not properly controlled, radioactive isotopes have negative affects on humans and the environment.

Transformation and Conservation of Matter

2.21 Chemical reactions which take place between the atoms and molecules of elements and compounds

occur all around us, for example, combustion, rusting of iron, growing of plants, and cooking of foods. Complex chemical reactions take place constantly in every cell of the human body. A chemical equation represents, with symbols and formulas, the reactants and products in a chemical reaction.

2.22 Virtually all chemical reactions release or absorb energy. During chemical reaction, energy in the form of heat, light, or electricity is absorbed in the breaking of bonds or released when new bonds are formed. The rate of a chemical reaction depends on the properties and concentration of the reactants, temperature, and the presence or absence of a catalyst. A catalyst changes the rate of a chemical reaction by interacting with the reacting species but is not consumed in the overall reaction.

2.23 A large number of reactions, usually in solution, that are important in non-living and living systems, involve the transfer of either electrons (oxidation/reduction) or hydrogen ions (acid/base reactions).

2.24 Regardless of how atoms and molecules in a closed system interact with one another, or how they combine or break apart, the total weight of the system remains the same. (Benchmark for Scientific Literacy, 1993).

2.25 Certain small molecules (monomers) react with one another in repetitive fashion (polymerization) to form long chain macromolecules (polymers). The properties of the macromolecules depend on the properties of the molecules used in their formation and on the lengths and structure of the polymer chain. Polymers can be natural such as DNA, hair, skin, spider webs, and silk or synthetic such as polyethylene and nylon. Natural polymers are essential to cellular structure and cellular processes; synthetic polymers are the basis of an industry which provides a variety of fibers, plastics, films, and coatings.

Mixtures and Solutions

2.31 Mixtures have variable compositions and are either homogeneous or heterogeneous. A homogeneous mixture (solution) has the same properties throughout whereas a heterogeneous mixture consists of two or more phases that differ in properties. The formation of a mixture is a physical change; therefore, mixtures can be separated into their component parts without conducting a chemical reaction.

2.32 A variety of methods are used to prepare mixtures and to separate mixtures into their component parts. These methods such as blending, grinding, use of surfactants, distillation, floatation, and filtration are used throughout the scientific and industrial world.

2.33 The properties of solutions depend upon the concentration, properties, and interactions of the solute and solvents.

Material Technology

2.41 The properties of materials determine how they are used by society. New material discoveries are being used to improve the quality of life; however, their development often raises social, economic, and environmental issues.

Standard #3 - Energy and Its Effects

Forms/Sources of Energy

3.11 Electromagnetic radiation is a form of energy which can exhibit both wave and particle characteristics and does not require a material medium for its transmission. The energy of the radiation depends on

both the intensity (brightness) and frequency.

3.12 Electricity results from the movement of electric charges through a complete circuit under the influence of an applied voltage. The electric current flowing in any circuit or part of a circuit depends on the voltage and resistance and can be calculated using Ohm's Law.

3.13 Electric forces between charged objects are attractive or repulsive. The electric forces between electrons and protons are attractive, determine the structure of atoms, and are involved in all chemical reactions. The electromagnetic forces acting between atoms or molecules are much stronger than the gravitational forces between the same atoms or molecules and are responsible for the physical and mechanical properties of materials (e.g., frictional forces, force of a compressed spring, surface tension, or boiling point of a liquid).

3.14 Magnetic forces and electric forces are thought of as different aspects of a single electromagnetic force. Moving electric charges produce magnetic fields which exert magnetic force on other objects and produce electric forces. The interaction of electric and magnetic forces is the basis for electric motors, electric generators, and many other modern technologies.

3.15 Chemical energy is derived from the gain or loss of electrons between atoms during the making and breaking of chemical bonds. The energy released or absorbed in a chemical reaction can be predicted and measured. The rate of many chemical reactions can be increased by raising the temperature or by adding catalysts in order to reduce the activation energy.

3.16 Nuclear energy is released as heat, light, or radiation when a portion of the mass of the nucleus is converted to energy. The nuclear forces which hold the nucleus of an atom together are much stronger than the repulsive electric forces between protons which would make the nucleus fly apart; therefore, most atoms have stable nuclei. When nuclear decay does occur, very large amounts of energy are released - See also *Materials and Their Properties*.

Force and Motion

3.21 A force acting on an object and moving it through a distance does work on that object and changes it's kinetic energy (energy of motion), potential energy (energy of position), or both. The ratio of output work to input energy is the efficiency of the machine or process and is always less than 100%. Power is the rate at which the work is done.

3.22 Displacement, velocity, acceleration, and time are used to describe the motion or changes in the motion of an object.

3.23 Objects can have linear motion, rotational motion, or both. Newton's Laws can be used to predict changes in linear motion and/or rotational motion. Momentum allows objects to remain in motion after the applied force is removed. The Law of Conservation of Momentum can be used to predict the outcomes of a collision between moving objects.

Transformation and Conservation of Energy

3.31 Energy can be transformed from one form into another, but the total energy is constant in a closed system. The amount of energy involved in any process, and the rate at which it is generated or consumed can be discussed qualitatively and measured. Some heat is released or absorbed in most energy transformations.

3.32 Energy can be transferred from one place to another by gross movement of material (e.g., wind, waterfalls, thrown ball), by mechanical waves moving through a material medium (e.g., sounds,

earthquakes, tidal waves), or by electromagnetic waves (e.g., light, microwaves). The observed wavelength of a wave depends on the relative motion of the source and the observer and can be shorter or longer than the actual wavelength, depending on whether the relative motion is towards the source or away from the source respectively. This apparent change is called the Doppler Effect.

3.33 Mass is converted to large quantities of energy in the processes of nuclear fission and fusion. The energy released can be calculated using the equation $E=mc^2$. The total of energy and mass is constant in these processes.

Interactions of Energy and Materials

3.41 Energy waves may interact with materials leading to the formation of heat or other forms of energy. These interactions, which depend upon the nature of the material and the wavelength of the radiation, can be used to create practical devices such as electric heaters, solar cells, remote control units, and optical communication devices.

3.42 When radiation energy is absorbed or emitted by individual atoms or molecules, the changes in energy involve the jump of an electron from one distinct energy level to another. These energy changes, which are characteristic of the atom or molecule, can be used to identify the material.

Production/Consumption/Application of Energy

3.51 Demand for energy by society leads to continuous exploration in order to expand supplies of fossil fuels (e.g., drilling deeper oil and gas wells, drilling offshore). In addition, technology has been developed to create alternate energy sources (e.g., solar collection, ocean thermal energy conversion) and to increase the energy efficiencies of commonly used machines and appliances.

3.52 Advances in the scientific understanding of synthetic materials have provided new devices (e.g., transistors, light emitting diodes, optical switches, superconducting ceramics) used in electronic equipment. This has revolutionized many aspects of life (e.g., communications, manufacturing, information processing, and transportation).

3.53 The increase in energy demand has environmental consequences, and societal expectations for a sustainable environment will require new, cleaner technologies for the production of energy.

Standard #4 - Earth in Space

Solar System Models

4.11 The Solar System is a very small part of a constantly changing Universe. Stars, including the Sun, appear to go through cycles that are characterized by birth, development, and death. Existence of gas and dust around nearby stars supports the theory that planetary systems continue to evolve.

4.12 The stars in the Milky Way Galaxy are separated by vast distances. Although it takes light from the Sun eight minutes to reach the Earth, it takes the light from the next nearest star four years to reach Earth. Light which reaches Earth from distant galaxies is millions of years old and is actually a view of the past.

4.13 The distance from the center of the nebula to points of condensation determined the position of the planets in the Solar System. The masses of the condensed protoplanets determined which elements were

retained, as well as their physical state.

4.14 The tilt of the Earth's axis relative to its orbital plane does not change as the Earth orbits the Sun during a year. Seasonal variations of the apparent path of the Sun through the sky determine how directly the Sun's rays strike and warm different areas of the Earth.

Interactions in the Solar System

4.21 Gravitation pulls planets toward the Sun balancing each planet's energy of motion. The gravitational pull of the Sun and the Moon determine the times for high tides and the intensity of these tides on Earth.

4.22 Solar energy radiates through space and is distributed on Earth by radiation, conduction, and convection. Energy transfer powers atmospheric and oceanic circulation.

Technology and Application

4.31 Space exploration expands our knowledge of the Universe and advances the technological sophistication of society.

Standard #5 - Earth's Dynamic Systems

Components of Earth

5.11 Long term exposure of rocks to different environments results in weathering and decomposition and the production of soils and sediments. Differences in the geographical origin of rock materials lead to variations in the physical properties and chemical composition of soil.

5.12 A mixture of gases, water vapor, and solid particles comprise the Earth's atmosphere. Variations in atmospheric composition caused by either natural or human activities influence life on Earth.

5.13 Sub-surface water is a limited resource and must be judiciously managed. The rate of movement of sub-surface water is controlled by differences in elevation and the porosity and permeability of the rock and soil through which it moves.

Interactions Among Earth's Systems

5.21 The theory of plate tectonics is supported by structural evidence (volcanoes, plateaus, mountain ranges) geophysical evidence (earthquake waves, magnetic reversals in rock), and paleontological evidence (biological similarities between flora and fauna of widely separated continents).

5.22 Movement of tectonic plates releases energy, bringing new materials to Earth's surface, which balances the effects of erosion and weathering.

5.23 Physical features of Earth result from a balance of processes that elevate and wear down land surfaces and move materials from higher to lower elevations.

5.24 Radiation from the Sun drives the circulation of air and water around the Earth leading to a variety of weather phenomena and regional climates.

Technology and Applications

5.31 The understanding of global and local changes that result from the interactions of ocean systems has increased substantially as a result of continuous advances in science and technology.

5.32 Both relative and absolute means are used to determine the ages of rocks and the sequence of geological events. The relative age of sedimentary rock is determined by the chronological record of geological strata and fossils, and the absolute age is determined by radioactive dating.

Standard #6 - Life Processes

Structure/Function Relationship

6.11 Cells are the fundamental structural and functional units of all living organisms. Cells take highly varied forms in different plants, animals, and microorganisms. Structural variations among cells determine the function each cell performs.

6.12 Cells have distinct and separate structures (organelles) which perform and monitor processes essential for survival of the cell (e.g., energy production, waste disposal, synthesis of new molecules, storage of genetic material). The highly specific function of each organelle is directly related to its structure.

6.13 The cell membrane defines the boundary of the cell and regulates the passage of materials into and out of the cell. Transport mechanisms across the membrane are dependent on membrane structure and concentration gradients.

6.14 Cells store and use information to guide their functions. DNA molecules in each cell carry coded instructions for synthesizing protein molecules. The protein molecules have important structural and regulatory functions.

Matter and Energy Transformations

6.21 Cells carry out a variety of chemical transformations which allow conversion of energy from one form to another, the breakdown of molecules into smaller units, and the building of larger molecules from smaller ones. Most of these transformations are made possible by protein catalysts called enzymes.

6.22 Plant cells contain plastids which convert light energy into chemical energy through the process of photosynthesis. This chemical energy is used by the plants to convert carbon dioxide and water into high energy food molecules such as lipids and carbohydrates. Photosynthesis adds oxygen to the atmosphere and removes CO_2.

6.23 All organisms including plants, use the process of cellular respiration to transform high energy food molecules produces during photosynthesis into energy. The energy produces is stored in the phosphate linkages of ATP and is used by organisms to conduct their life processes. Cellular respiration may require oxygen and adds carbon dioxide to the atmosphere.

6.24 Photosynthesis and cellular respiration are complimentary processes to the flow of energy and the cycling of matter in ecosystems.

Regulation and Behavior

6.31 In multicellular organisms, cells perform specialized functions as parts of sub-systems (e.g., tissues, organs, and organ networks) which work together to maintain optimum conditions for the benefit of the whole organism. Coordination of these functions is accomplished by a specialized cells or groups of cells that monitor stimuli from the organism's internal and external environment enabling the organism to respond to changing environmental conditions.

6.32 Behavioral responses result from interactions between organisms of the same species or different species as well as from environmental changes. These responses can be innate or learned and have evolved to insure reproductive success of the species.

Health and Technology Applications

6.41 Certain chemicals, pathogens, and high energy radiation seriously impair normal cell functions and the health of the organism.

6.42 The scientific investigation of cellular chemistry enables the biotechnology industry to produce medicines, foods, and other products for the benefit of society.

Standard #7 - Diversity and Continuity of Living Things

Heredity

7.11 Heredity/genetic information in chromosomes is contained in molecules of DNA that consist of various combinations of four different subunits (nucleotides) that encode this information. Genes are sections of DNA that direct syntheses of specific proteins associated with traits in organisms.

7.12 Principles of Mendelian genetics are useful in determining the pattern of inheritance for many traits.

7.13 Gene mutations are alterations in normal DNA structure which can be caused by coding error in DNA synthesis, heat, radiation and certain chemicals. Mutations may be beneficial, harmful, or neutral to cell function and can be passed on to an organism's offspring. Somatic mutations are not heritable.

Reproduction and Development

7.21 During the cell cycle, DNA of the parent cell replicates to form identical chromosomes and genes and the cell divides into two identical offspring cells.

7.22 During the cell division process that forms gametes (meiosis), the number of chromosomes is reduces by one-half and genes are shuffled and recombined. The sorting and recombination of genes in sexual reproduction result in a great variety of possible gene combinations in the offspring.

7.23 Embryological development in plants and animals involves a series of orderly changes in which cells divide and differentiate. Development is controlled by genes whose expression is influenced by many

internal and external factors.

Evolution

7.31 The process of natural selection occurs when some heritable variations that arise from mutation and recombination give individuals within a species some survival advantages over others. These advantaged offspring are more likely to survive and reproduce, thus increasing the proportion of individuals with advantageous characteristics. New species may form when populations become isolated from each other.

7.32 Evolution does not proceed at the same rate in all organisms; nor does it progress in some set direction. Some organisms have remained relatively unchanged for millions of years while other have died out altogether. In addition, some complex organisms have evolved from simple unspecialized forms of life (e.g., green algae to vascular plants), while other species are the result of complex life forms evolving to simple forms (e.g., winged birds to flightless birds). Environmental changes have a strong influence on this whole process.

Diversity

7.41 Organisms are classified into a hierarchy of groups and subgroups, based on structural similarities and evolutionary relationships.

7.42 Similarities in DNA and protein structure are used to classify and determine degrees of kinship among organisms.

7.43 Variations of organisms within a species and diversity among species increase the likelihood that at least some organisms will survive major changes in the environment.

Health and Technology Applications

7.51 The expanding ability to manipulate genetic material, reproductive processes, and embryological development are being used to diagnose and treat human abnormalities as well as manufacture new consumer products. These applications raise many ethical, legal, social, and public policy questions.

7.52 Recombinant DNA technology, which is a form of genetic engineering, involves the insertion of DNA from one cell into another cell where the inserted DNA is expressed. Genetic engineering is being applied in many areas of biology, agriculture, and medicine.

7.53 DNA is analyzed to study populations, identify individuals, and diagnose genetic disorders.

Standard #8 - Ecology

Flow of Matter and Energy in Ecosystems

8.11 The supply of nutrients and the efficiency of solar energy transformations are two major factors which ultimately determine the number of organisms and species in an ecosystem.

8.12 The law of conservation of matter applies to ecosystems. Matter needed to sustain life in ecosystems is continually recycled (e.g., carbon cycle, water cycle, nitrogen cycle, mineral cycles) among organisms and between organisms and the environment.

8.13 The law of conservation of energy applies to ecosystems. All energy is conserved as it passes from the Sun through an ecosystem. During energy transformations some energy is converted to biologically unusable waste heat which is eventually lost and replenished by a continual input of solar energy.

8.14 Each species in an ecosystem occupies the niche for which it is best suited. In general, no two species occupy the same niche. This allows different species to coexist successfully and helps to maintain the stability of the ecosystem.

Changes in Ecosystems

8.21 Earth's ecosystems are interconnected by biological, chemical, and physical processes. Changes in one ecosystem may have local or global consequences.

8.22 Ecosystems are reasonably stable over long periods of time and tend to have cyclic fluctuations around a point of equilibrium. An ecosystem can react to stabilize conditions (e.g., pH, nutrient reduction, temperature, disease) and restore itself to its original state. Ecosystems undergo major changes as a result of such factors as climatic change, introduction of new species, and habitat destruction.

8.23 Ecosystems have a carrying capacity for each species. Overpopulation can lead to depletion of resources and elimination of species.

Interaction of Humans Within Ecosystems

8.31 All organisms are dependent upon the Earth's finite supply of material resources to sustain life. Human decision concerning the use of resources alters the stability and the biodiversity of ecosystems and adversely affect the natural recycling processes which maintain the quality of air, water, and land.

8.32 The availability of and access to natural resources shape the economic policies of society and form a basis for international trade agreements. Unequal distribution of resources and increased demand for natural resources require global cooperation and long-term planning to satisfy the resource needs of successive generations.

8.33 People manage the Earth and its resources by preservation, conservation, appropriate utilization, and restoration. There is a wide variety of national laws (e.g., CLEAN AIR ACT, CLEAN WATER ACT, ENDANGERED SPECIES ACT) and state laws (e.g., COASTAL ZONE ACT) that exist to protect the environment.

Technology and Its Influence on the Environment

8.41 Continuous growth in human population and depletion of land suitable for forming require farmers to

rely on modern agricultural technologies to meet demands for increased crop yields. The use of these technologies, however, involves economic and environmental tradeoffs.

8.42 The development of massive transportation systems has enabled the movement of population and goods by air, land, and water and has led to major changes in demographics and land use.

PERFORMANCE INDICATORS

Level One
(Grade 9)

Motion, Force, and Mechanical Energy

Force must be used to change speed or direction (or both) of a moving object. Any change in motion depends upon the amount of force causing the changes and the mass of the object. In the absence of such a force, the object will continue to move with the same speed and in the same direction.

9.01 Sketch graphs (distance vs. time) to represent the motion of an object at constant speed and then at constantly changing speeds as displayed by motion detectors, strobe photography, ticker tape timing, stopwatches, etc. **Standard(s) 3.22**

9.02 Calculate the average speed (v = d/t) for an object in motion using data acquired by probe technology or other means (stopwatches, strobe photography, etc.). **Standard(s) 3.22**

9.03 Interpret a distance vs. time graph of an object moving at a constant speed and calculate its average speed (i.e. finding the slope of the line.). **Standard(s) 3.22**

9.04 Analyze a series of graphs to identify those graphs that represent objects moving at constant speed versus those moving at constantly changing speeds, as detected by motion detectors, strobe photography, ticker tape timing, stopwatches, etc. **Standard(s) 3.22**

9.05 Conduct investigations to identify forces (e.g., friction, tension, gravity, etc.) acting on the object of investigation when forces are either balanced or unbalanced. **Standard(s) 3.23**

9.06 Observe and describe (in qualitative terms) the motion of an object when forces acting upon that object are balanced or unbalanced. **Standard(s) 3.23**

9.07 Calculate the net force on an object in motion by measuring the object's mass and its acceleration using F=ma. **Standard(s) 3.23**

9.08 Design and conduct a series of investigations to determine how changing an object's mass and forces acting on that object (tension, friction, etc,) affect its motion. **Standard(s) 3.23**

A force acting on an object and moving through a distanced does work on that object and changes its kinetic energy (energy of motion), potential energy (energy of position) or both.

9.09 Use data obtained from force and motion investigations to calculate the work done (W = Fd) to

move an object horizontally. Recognize that when work is done on an object (in a frictionless environment) it gains mechanical energy and the mechanical energy of moving objects is defined as kinetic energy. **Standard(s) 3.21**

9.10 Use appropriate instrumentation to collect data in order to calculate the work done to lift an object to the top of an inclined plane. Recognize that when work is done on an object, it gains mechanical energy and that the mechanical energy stored by an elevated object is defined as potential energy. **Standard(s) 3.21**

9.11 Determine how changing the angle of inclination of an inclined plane effects the final speed of a moving object. **Standard(s) 3.21, 3.22**

9.12 Use data obtained from inclined plane investigations to calculate potential energy ($PE = mgh$) and kinetic energy ($KE = 1/2mv^2$) at various positions on the plane. **Standard(s) 3.21**

9.13 Recognize that an object's potential energy at the top of an inclined plane is transformed into kinetic energy as the object moves down the incline plane. **Standard(s) 3.21**

9.14 Recognize that the potential energy at the top of the inclined plane is equal to the object's kinetic energy at the bottom of the inclined plane plus energy transformed into heat energy by frictional forces. **Standard(s) 3.21, 3.31**

Energy can be transformed from one form into another, but the total energy is constant in a closed system. Some heat is released or absorbed in most energy transformations.

9.15 Design and conduct investigations to determine how frictional forces related to varying surface conditions affect the motion of an object. **Standard(s) 3.23**

9.16 Use data from frictional force investigations to calculate the amount of mechanical energy transformed into heat energy by frictional forces. (e.g., $KE_{smooth} - KE_{rough\ surface}$ = Energy transformed into heat energy by frictional forces.) **Standard(s) 3.21, 3.31**

9.17 Construct a transfer of energy diagram to illustrate that the total energy remains constant in motion, force, and energy investigations.
Standard(s) 3.31

9.18 Explore other forms of energy that can be transformed from mechanical energy, such as the mechanical energy in a hand-cranked generator → electrical energy → heat and light energy.
Standard(s) 3.31

9.19 Explain using multiple examples, that any energy transfer or transformation results in some loss of energy in the form of heat which may spread by radiation, conduction or convection. **Standard(s) 3.31**

Properties and Structure of Matter

The periodic table groups elements according to similar chemical and physical properties. Organization of the periodic table makes it useful for predicting the properties and behavior of elements.

9.20 Explore the extent to which a variety of solid materials conduct electricity in order to rank the materials from good conductors to poor conductors. Based on the conductivity data, determine patterns of location on the periodic table for the good conductors versus the poor conductors. **Standard(s) 2.12**

9.21 Explore the extent to which a variety of liquids (solutions) conduct electricity in order to rank the liquids from good conductors to poor conductors. Based on the conductivity data, determine patterns of location on the periodic table for the elements in the good conducting solutions versus the poor conducting solutions. **Standard(s) 2.12, 2.33**

9.22 Investigate differences between the properties of metallic and nonmetallic elements and predict whether an element is a metal, a nonmetal or a semi-metal (metalloid or semi-conductor) due to its position on the periodic table.
Standard(s) 2.12

9.23 Use the periodic table to indicate the physical state of an element under normal conditions of temperature and atmospheric pressure. **Standard(s) 2.12**

9.24 Identify a few of the most common elements in the earth's crust, oceans, and atmosphere and confirm their location on the periodic table. (Example: Si, O, C, N, H, Al) **Standard(s) 2.12, 5.11, 5.12**

Variation in the physical and chemical properties of elements is related to the electron configuration of their atoms. The physical and chemical properties of materials determine the character and use of the material.

9.25 Use atomic models to explain that matter is composed of tiny particles called atoms that are unique to each element, and that atoms are composed of subatomic particles called protons, neutrons, and electrons. **Standard(s) 2.11**

9.26 Describe the relative charge, approximate mass, and location of protons, neutrons, and electrons in an atom. **Standard(s) 2.11**

9.27 Construct or diagram simple atomic models of common elements from Groups I and II, Groups VI and VII, and the noble gases on the periodic table to identify patterns of electron configuration. **Standard(s) 2.11, 2.12, 2.14**

9.28 Explain how an atom's electron arrangement influences its ability to transfer or share electrons

and determines its position on the periodic table. Recognize that an atom in which the positive and negative charges do not balance is an ion. **Standard(s) 2.12, 2.13, 2.14**

9.29 Construct models or diagrams of common compounds and molecules (i.e. NaCl, SiO_2, O_2, H_2, CO_2) and distinguish between ionically and covalently bonded compounds. Based on the location of their component elements on the periodic table, explain the elements tendency to transfer or share electrons. **Standard(s) 2.13, 2.14**

9.30 Describe the physical state of a variety of materials and the relationship between the physical state and the amount of attraction between the particles (molecules) of the specific material. **Standard(s) 2.14**

9.31 Apply the kinetic molecular theory to explain that the energy associated with the motion of the particles is kinetic energy and that as the particles gain more kinetic energy, a change of state may occur. **Standard(s) 2.15**

9.32 Conduct and explain investigations to determine the difference between physical and chemical changes of a substance. Recognize that chemical changes involve a chemical reaction in which a new substance is produced. The new substance may be a solid, liquid, or gas. **Standard(s) 2.21, 2.31**

9.33 Conduct and explain the results of simple investigations to demonstrate that the total mass of a substance is conserved during both physical and chemical changes. **Standard(s) 2.24**

9.34 Recognize that elements and compounds are homogeneous substances that have relatively constant properties. Mixtures are heterogeneous substances that are combined from two or more substances. **Standard(s) 3.23**

9.35 Conduct experiments to separate mixtures into their component parts (distillation filtration). Explain how the properties of the component parts determine the physical separation techniques used. **Standard(s) 2.31, 2.32**

9.36 Classify a variety of common materials as an element, compound or mixture. **Standard(s) 2.12, 2.13, 2.31**

9.37 Differentiate between physical and chemical properties of a variety of materials and explain how the properties determine the character and use of the materials. **Standard(s) 2.41**

Without water and its unique properties, life on Earth as we know it would not exist. To understand why water has such unique properties, it needs to be examined at the molecular level.

9.38 Construct a model or a diagram of the water molecule and use the model or diagram to explain waters' unique properties (e.g., polarity, hydrogen bonding, density, high boiling point, ionization, cohesion, and adhesion). Cite specific examples of how these properties are important in sustaining life on Earth. **Standard(s) 2.14**

9.39 Construct visual representations (or use computer simulations) to describe the spatial arrangement of water molecules in the three states of matter. **Standard(s) 2.14, 2.15**

9.40 Conduct investigations to determine the effect of heat energy on the change of state of water molecules. Sketch and interpret graphs representing the melting, freezing, evaporation and condensation of water. **Standard(s) 2.15, 3.31**

9.41 Test water's ability to dissolve a large number of different substances. Use models of water molecules to explain what happens when a substance such as salt dissolves in water, and when a substance such as oil does not. **Standard(s) 2.33**

9.42 Investigate factors that effect the solubility of common materials in water and construct solubility curves to compare the extent to which the materials dissolve. **Standard(s) 2.33**

9.43 Design and conduct an investigation to verify that substances react more readily in solution than in solid form and relate this phenomena to living organisms requirement for water. **Standard(s) 2.14, 2.23, 2.33**

9.44 Measure the hydrogen ion level of solution using pH paper or probe technology and describe how the pH scale indicates the degree of acidity of a solution. **Standard(s) 2.33**

Interaction of Matter and Energy in Earth's Systems

Minerals and rocks change when they are subjected to the physical and chemical conditions existing on Earth's surface. The rate at which physical and chemical weathering occurs is determined in part by the properties of the material being weathered; climatic variables, such as precipitation and weather; and the acidity of rain water.

9.45 Differentiate between mechanical and chemical weathering and identify several examples of each. Recognize that mechanical weathering results in physical change that does not alter the chemical composition of rock, and that chemical weathering results in chemical change where rocks decompose and new chemical substances or compounds are formed. **Standard(s) 5.11**

9.46 Identify climatic variables (e.g., precipitation and temperature), and explain how these variables affect the rate of mechanical and chemical weathering and influence the formation of geologic land features. **Standard(s) 5.11**

9.47 Investigate the relative rate at which acidic solutions (most effective agents of chemical weathering) dissolve a variety of common rock material (e.g., limestone, marble). **Standard(s) 2.33, 5.11, 5.12**

9.48 Determine the effects and relative rate of physical and chemical weathering on local area structures composed of earth materials (e.g., buildings, sidewalks, and tombstones) and relate the results to previous weathering investigations. Explain how the properties and composition of earth materials affect the degree of weathering observed. **Standard(s) 5.11, 5.12**

9.49 Identify possible factors that could account for differences in the acidity levels of precipitation samples by testing the pH of local precipitation over time. **Standard(s) 2.33, 5.12**

9.50 Differentiate between normal precipitation with a pH approximately 5.6 and precipitation that has become more acidic due to human influence. Explain why precipitation could accelerate the weathering processes on a variety of structures. **Standard(s) 2.33, 5.12**

Weathering processes create soil. The character of the soil depends partly on the parent rock from which it develops.

9.51 Identify some common rock forming minerals and the elements from which they are comprised. Examine the physical properties of the identified minerals to determine their rate of weathering and to match the properties with the appropriate mineral. **Standard(s) 2.12, 2.14**

9.52 Examine a variety of rocks to determine the major rock type (igneous, metamorphic, sedimentary) and to explain how the processes by which the rocks form influence their rate of weathering. **Standard(s) 5.11**

9.53 Examine local soil samples to identify their living and nonliving components and the type of parent material from which the samples could come. **Standard(s) 5.11**

9.54 Determine properties of local soil samples, such as pH and permeability. Investigate how these properties affect local vegetation, crops, and land use decisions. **Standard(s) 5.11, 5.13**

9.55 Examine Delaware soil profiles to identify distinct layers and to compare and contrast composition and properties of different soil horizons. **Standard(s) 5.11**

9.56 Explore the rate at which water permeates through local soil samples. Use simple molecular models to explain why certain soil samples (clay) retain water longer than other soil samples. **Standard(s) 5.13**

9.57 Use molecular models to explain why substances (such as nitrates) permeate and diffuse through soil so quickly and present serious problems for many Delaware watersheds. **Standard(s) 2.14, 2.15, 8.31, 8.41**

9.58 Relate the Law of Conservation of Matter to physical and chemical weathering. Recognize that all of the atoms and ions that are products of weathering are equal to all the atoms and ions of the original rock that weathered.
Standard(s) 2.24, 5.11

Erosion physically removes and deposits rock particles in other locations to change the surface of the land.

9.59 Explain the hydrologic cycle and recognize that the movement of water is driven in part by solar energy. **Standard(s) 5.24, 5.31, 8.12, 8.13**

9.60 Identify environments (reservoirs) in which water is stored and recognize that even though water flows from one reservoir to another, there is not a net gain or loss of water on Earth. **Standard(s) 5.13, 5.24, 5.31, 8.12**

9.61 Use stream tables to study the effects of water as an agent of erosion that is driven by gravity and that produces
distinctive land forms. **Standard(s) 5.11, 5.23**

9.62 Design and conduct investigations (e.g., changing the slope of a stream table or increasing the volume of water) to determine the relationship between erosion and the speed of moving water. Relate the results of the investigation to results obtained from previous force and motion investigations. **Standard(s) 3.22, 5.13, 5.23**

9.63 Determine using stream tables how streams and rivers transport sediments (products of weathering such as sand, silt, and mud) and where the sediments are usually deposited. **Standard (s) 5.11, 5.23**

9.64 Recognize that once sediment is buried, additional deposits can accumulate turning the sediments into sedimentary rock. Relate the Law of Conservation of Matter to this phenomenon. **Standard (s) 2.24, 5.11**

9.65 Investigate the rate at which soils are eroding in Delaware. Explain why soils take such a long time to form and identify
practices that can minimize the consequences of erosion. **Standard(s) 5.11, 8.41**

Interaction of Matter and Energy in Living Systems

Foods are compounds composed of elements such as carbon, hydrogen, oxygen, nitrogen, etc. Plants use light energy from the sun and absorb elements from the atmosphere and soil to make specific food compounds. Food compounds produced by plants serve as a source of matter and energy for all living things.

9.66 Conduct tests for specific compounds and use the tests to determine which compounds are found in ordinary foods. **Standard(s) 6.21**

9.67 Observe formulas and diagrams of compounds found in food (fats, proteins, carbohydrates). Identify elements that comprise these compounds. **Standard(s) 2.13, 2.14, 6.21, 6.22**

9.68 Recognize that during photosynthesis, plants use solar energy and elements from the atmosphere and the soil to make specific compounds. Recognize that these compounds are used by living things as sources of matter and energy. **Standard(s) 6.22, 6.23, 6.24**

Food must be physically and chemically broken down in order to be absorbed into the bloodstream. Once food molecules enter the bloodstream, they serve as building blocks for the syntheses of body structures.

9.69 Investigate the role digestion plays in breaking down food into compounds and molecules. Conduct tests to study the importance of mechanically breaking down food (chewing) and the effects of salivary amalase on starch. Explain the difference between the mechanical breakdown of food which involves a physical change, and the breakdown of large food molecules to small molecules (e.g., starch to glucose, lipids and glycerol to fatty acids, proteins to amino acids) which involves a chemical change. **Standard(s) 2.21, 6.21**

9.70 Construct models (dialysis tubing) of the small intestine to identify which compounds or molecules are able to move through a semi-permeable membrane. Relate how the size of molecules determines their ability to be absorbed directly into the blood stream from the small intestine and broken down into simple sugars. **Standard(s) 6.13**

9.71 Speculate as to how molecules in the previous investigations move through a membrane. Describe the movement of molecules from an area of higher concentration to an area of lower concentration (diffusion). **Standard(s) 6.13**

9.72 Trace the pathway of food from the mouth through the digestive system. Recognize that once specific food molecules enter the bloodstream, they serve as building blocks for the synthesis of body structures (i.e. "you are what you eat"). **Standard(s) 6.21**

Elements and compounds used in the building of Earth's geological structures and the bodies of living organisms are the same. Because no alternative source of matter exists, the cycling of matter between living and non-living things is essential.

9.73 Analyze geochemical cycle diagrams and explain how matter is continually cycled between the living and nonliving environment. (Conservation of Matter). **Standard(s) 2.24, 8.12**

9.74 Construct a diagram or other visual aid to show a logical set of events that could explain how atoms such as carbon, hydrogen, oxygen, and nitrogen, which are basic components of human bodies, could have come from another organism or from a rock. **Standard(s) 8.12**

9.75 Explain how human activities impact geochemical cycles (e.g., the carbon cycle affects global warming or the nitrogen cycle contaminates groundwater), and identify measures that are being taken to minimize adverse environmental consequences associated with such human activity. **Standard(s) 8.21, 8.22, 8.23, 8.31, 8.32, 8.41**

Performance Indicators

Level Two
(Grade 10)

Chemical Reactions

Chemical reactions involve the breaking and or forming of chemical bonds causing atoms to become rearranged into new substances that have different properties from the original material. During a chemical reaction, energy is either absorbed or released when chemical bonds are formed or broken.

10.01 Conduct experimental observations and cite evidence (e.g., formation of a precipitate, evolution of gas, change of color, release/absorption of energy in the form of heat, light, or sound) as to whether or not a chemical reaction has occurred. **Standard(s) 2.21, 2.22, 2.23**

10.02 Analyze chemical equations for a variety of common types of reactions (e.g., synthesis, decomposition, replacement and combustion) and identify the reactants and products in the equation. **Standard(s) 2.21, 2.22**

10.03 Identify the number of atoms on each side of a chemical equation to determine if the equation is balanced. Recognize that balanced chemical equations illustrate that the mass of the products is equal to the mass of the reactants. (Conservation of matter). **Standard(s) 2.21, 2.24**

10.04 Investigate factors (e.g., presence of a catalyst, temperature, concentration) that influence the rate at which reactions occur. Construct simple diagrams to demonstrate and to explain that activation energy is required for the reaction to reach the transition state (the point at which the system has the highest potential energy) and that there is an energy difference between reactants and products. **Standard(s) 2.22**

10.05 Analyze reaction diagrams for some common chemical reactions to compare the amount of heat energy absorbed by the reaction to the amount of heat energy released. Explain using the diagrams that if the products of the reactions are at a higher energy level than the reactants, then the reaction has absorbed heat energy (endothermic), but if the products of the reaction are at a lower energy level than the reactants, then heat energy has been released (exothermic). **Standard(s) 2.22, 3.15**

10.06 Recognize that in general, synthesis reactions require energy while decomposition reactions usually release energy. **Standard(s) 3.15**

Chemical Reactions and Energy Transfer in Life Processes

The energy organisms need to perform essential life processes, initially comes from the sun. Plants are able to absorb light energy and convert it into chemical energy which is stored in sugars by the plants. As other organisms metabolize these sugars, some of the energy escapes as heat.

10.07 Use data obtained from investigations to explain the processes used by autotrophs to capture light energy and produce molecules such as simple sugars and starch. Measure the rate of photosynthesis and recognize that photosynthesis is an endothermic reaction in which sunlight is continually needed if carbohydrates are to be synthesized. **Standard(s) 3.15, 3.31, 6.22, 8.11**

10.08 Identify the reactants and the products in an equation that represent photosynthesis. Explain how the equation demonstrates the Law of Conservation of Matter. **Standard(s) 6.22, 6.23. 6.24**

10.09 Calculate the relative amount of chemical potential energy stored in chemical bonds of a variety of foods. Recognize that all matter does not contain the same amount of energy. **Standard(s) 3.15, 6.23**

10.10 Explain that as organisms break down the high energy compounds in foods, some of the energy escapes as heat. Construct diagrams to illustrate this point. **Standard(s) 3.31**

10.11 Analyze a variety of graphs or pyramids (e.g., pyramids of numbers, pyramid of biomass, pyramid of energy) that represent energy flow in food chains and food webs. Explain why in general, fewer organisms can be supported at each trophic level of the pyramid and why sunlight needs to be continually fed into the system. **Standard(s) 8.11, 8.13**

10.12 Investigate where humans position themselves on the food chain. Describe individual and global benefits that could be realized from humans eating at a lower trophic level. **Standard(s) 3.31, 8.11, 8.13**

10.13 Investigate how seasonal variations in solar energy in an ecosystem affects the biomass of producers. Relate this variation to the total number of consumers the system supports and identify ways in which ecosystems reduce energy demands during times of decreased solar energy input (e.g., leaves falling, estivation, migration). **Standard(s) 4.14, 8.11, 8.13**

10.14 Investigate the effect of human induced changes on the population size and the diversity of organisms found in an ecosystem. Explain the effect of the changes on the amount of energy available at each trophic level of the ecosystem. **Standard(s) 8.13, 8.31, 8.32, 8.33**

Cell Structures and Function

Structural variations in cells are related to the different functions they perform. Although there is no one common cell, all cells are organized around a similar plan.

10.15 Use microscopes to observe a variety of cells from each of the kingdoms. Identify similarities and differences among the cells and explain how structural variations determine the function that each of the cells perform.
Standard(s) 6.11, 6.12

10.16 Describe the differences in the complexity of cells. Distinguish between cells (prokaryotes) that

are relatively simple with no true nucleus from cells (eukaryotes) that have more complex organization with a true nucleus and membrane bound organelles. **Standard(s) 6.12, 6.13**

10.17 Observe cellular models to identify major organelles. Select several of the cellular organelles and explain how the highly specialized functions of each is directly related to its structure. **Standard (s) 6.12, 6.13**

10.18 Use microscopes to observe the chloroplasts of a plant cell. Recognize that these organelles specialize in the process of photosynthesis. Relate the structure of the chloroplast to the process of photosynthesis.
Standard(s) 6.12, 6.21, 6.22

The plasma membrane is a selective barrier that regulates what substances enter and leave the cell. Cell surface area to volume ratio affects the rate of diffusion into and out of the cell. Transport mechanisms across the membrane are dependent on membrane structure and concentration gradients.

10.19 Use demonstrations to explain the process of Brownian motion. Describe how the process of diffusion or the movement of molecules from an area of high concentration to an area of low concentration (down the concentration gradient) occurs because of molecular collisions.
Standard(s) 2.15

10.20 Recognize that the movement of water into and out of living cells is vital to life processes and that the diffusion of water through a semi-permeable membrane is referred to as osmosis.
Standard(s) 6.13

10.21 Distinguish between active and passive transport. Recognize that active transport requires energy in order to move molecules from an area of low concentration to an area of high concentration (against the concentration gradient). **Standard(s) 6.13**

10.22 Use fluid mosaic models of the plasma membrane to explain how its structure regulates the movement of materials across the membrane. **Standard(s) 6.13**

10.23 Design a controlled experiment to investigate the capacity of the cell membrane to regulate what enters and leaves the cell. Expose cells (e.g., chicken egg, plant cells) to solutions of different concentrations and explain the relationship between the solutions and the internal environment of the cell (hypotonic, isotonic, hypertonic). Relate the results of the investigation to every day examples of this phenomenon (e.g., food preservation using salt and sugar, dehydration from drinking seawater, rehydration of produce on grocery shelves by spraying with water). **Standard (s) 6.13**

10.24 Construct cell models (e.g., phenolphthalein-agar cubes, potato-iodine cubes) to investigate the relationship among cell size, surface area to volume ratio and the rates of diffusion into and out of the cell. Speculate why large organisms have developed from many cells rather than one large cell. **Standard(s) 6.13**

Biochemistry

Photosynthesis and cellular respiration are complimentary processes to the flow of energy and the cycling of matter in ecosystems. All organisms including plants use the process of cellular respiration to transform high energy food molecules produced during photosynthesis into energy for conducting life processes.

10.25 Manipulate molecular models to demonstrate that carbon is neither a strong electron acceptor nor a strong electron donor and is thus able to form covalent bonds with many elements. Use the molecular models to explain how carbon atoms uniquely bond to one another to form a large variety of molecules including those necessary for life.
Standard(s) 2.13, 2.14

10.26 Use molecular models or visual representations to explain why complex carbohydrates are polymers. Describe the process by which water is removed from sugar molecules (dehydration synthesis) to form carbohydrates and is added to break them down (hydrolysis).
Standard(s) 2.14, 2.25

10.27 Recognize that when chemical bonds between sugar molecules are broken (hydrolysis) energy is released and that
heterotrophs must break chemical bonds in food molecules during cellular respiration to obtain the energy needed for life processes. **Standard(s) 2.22, 2.25, 6.23**

10.28 Recognize that during cellular respiration, carbohydrates and other food molecules are broken down and transformed into chemical energy, ATP, and that in this form, energy can then be used to do cell work. (e.g., transporting materials across the cell membrane, conducting nerve impulses, contracting muscle fibers.). **Standard(s) 6.23**

10.29 Refer to the results of previous rate of reaction investigations and reaction diagrams to explain how enzymes lower the energy of activation and permit low temperature chemical reactions to occur in cells. **Standard(s) 2.22, 3.15, 6.21**

10.30 Select an enzyme substrate system (e.g., amylase/starch, protease/gelatin, catalase/hydrogen peroxide) and investigate factors that affect the rate of enzyme catalyzed reactions(e.g., temperature, light, pH, enzyme/substrate concentration). **Standard(s) 2.22**

10.31 Design investigations to develop reasonable explanations concerning the complimentary relationship (cycling of matter
and the flow of energy) between photosynthesis and cellular respiration. For example, a small snail, a water plant, a light source, and a pH indicator can be used as part of an experimental design to explain the relationship.
Standard(s) 6.23, 6.24, 8.12, 8.13

10.32 Analyze the equation for cellular respiration along with the equation for photosynthesis. Use the formulas to identify the reactants and products in each process and to explain the complimentary nature of the processes. **Standard(s) 2.21, 6.23, 6.24, 8.12, 8.13**

Transmission of Genetic Information from Cell to Cell and from Generation to Generation

When a cell reaches a certain size, it begins a series of changes that permit it to divide into two cells. During the doubling process, the generic information, or the DNA, is copied exactly.

10.33 Reanalyze data obtained from the cellular model investigations that determined the relationship among cell size, surface area to volume ratio and the rate of diffusion into and out of the cell. Relate the results of the investigation to the need for cells to divide in order to function efficiently. **Standard(s) 2.15**

10.34 Manipulate simple chromosomal models (e.g., 3-4 sets of chromosomes) to demonstrate that as a diploid cell replicates, it forms two new sets of identical chromosomes. **Standard(s) 7.11, 7.21**

10.35 Observe a series of pictures, slides or models that illustrate the stages of mitosis. Sequence the stages and describe distinctive differences observed in the chromosomes during the stages. **Standard(s) 7.21**

10.36 Recognize that genes are subunits of chromosomes and are composed of DNA molecules which transmit genetic information from cell to cell during mitosis. **Standard(s) 7.11, 7.21**

10.37 Construct models (pop beads, pipe cleaners) to demonstrate that DNA is a long twisted, double stranded polymer composed of small sub-units. Explain how the order of the sub-units on one strand of DNA provides a template that determines the order of the sub-units on the other strand of DNA. **Standard(s) 2.25, 7.11, 7.21**

10.38 Use DNA models to demonstrate that during mitosis when the DNA (chromosome) replicates the strands separate and the old strand serves as the template for the new complementary strand. Recognize that through this replication process, two identical strands of DNA are formed exactly like the original double stranded molecule. **Standard(s) 7.11, 7.21**

DNA code directs the synthesis of proteins associated with traits in organisms. Human ability to manipulate the code has ethical and economic implications for society.

10.39 Use models of DNA, RNA, and amino acids to demonstrate the mechanism by which DNA directs the synthesis of proteins. Explain that a gene is a section of DNA that directs the synthesis of a specific protein associated with a specific trait in an organism. Recognize that a gene mutation (change in the order of DNA subunits) can cause a structural change in a protein which

can result in the alteration of a trait. **Standard(s) 7.11, 7.13**

10.40 Investigate how the human ability to manipulate genetic material can be applied to many areas of medicine, biology, and agriculture. Discuss the ethical, legal, social, and public policy implications that these applications raise.
Standard(s) 7.51, 7.52

Through a special type of cell division known as meiosis, the chromosome number of gametes or sex cells is reduced by one half and genes are shuffled and recombined. During sexual reproduction, the diploid chromosome number is restored.

10.41 Recognize that during the formation of gametes or sex cells (meiosis) the number of chromosomes is reduced by one half and genes are shuffled and recombined. **Standard(s) 7.22, 7.31**

10.42 Construct cellular models (e.g., modeling clay, pop beads) to represent a male or female diploid animal that has a limited number of sets of chromosomes (e.g., 2-3). Track how meiosis affects the distribution of chromosomes and the shuffling of genes. **Standard(s) 7.22**

10.43 Demonstrate through the use of diagrams or models that meiosis promotes genetic diversity via crossing over, genetic recombination, mutations. **Standard(s) 7.13, 7.22, 7.31**

10.44 Observe karyotypes of human chromosomes (paired and sequenced) and differentiate between the autosomes and the sex chromosomes. **Standard(s) 7.53**

10.45 Use models to demonstrate that during meiosis, the gametes receive a single sex chromosome. Explain that during fertilization, a sex chromosome contributed by the mother and one contributed by the father determines the sex of the offspring. **Standard(s) 7.22, 7.31**

10.46 Use models or diagrams to demonstrate that the diploid chromosome number is restored during fertilization. **Standard(s) 7.22**

Patterns of inheritance for specific traits can be predicted and the probability of those traits being expressed can be determined.

10.47 Conduct simulation activities (e.g., use beans, kernels of corn, pop beads to represent alleles for a specific trait) to demonstrate how genetic information is passed from one generation to the next. Based on the results of the simulation, explain the basic principles of Mendelian genetics: inherited characteristics are controlled by genes occurring in pairs, a dominant gene can mask the effect of a recessive gene, a pair of genes separate during the formation of sex cells. **Standard(s) 7.12**

10.48 Use Punnett squares and pedigree charts to determine probabilities and patterns of inheritance such as dominant/recessive, codominance, sex-linkage, multi-allele inheritance. **Standard(s) 7.12**

10.49 Investigate patterns of inheritance for several well known human genetic disorders (e.g., autosomal recessive/cystic fibrosis, autosomal dominant/Huntington's Disease, sex linked/hemophilia). Explain the probability of offspring inheriting the disorder and the advances medical research has made in treating the disorder. **Standard(s) 7.12, 7.31, 7.51, 7.52, 7.53**

10.50 Perform probability activities (using pennies, candies, etc.) to simulate gender determination or the inheritance of a particular trait. Based on results of the activities explain the effect sample size has on the match between probable outcomes and predicted results. **Standard(s) 7.12, 7.31**

Species acquire many of their unique characteristics through biological evolution which involves the selection of naturally occurring variations in populations. Mutations (changes in DNA) and recombination are the sources of these variations which give some species survival and reproductive advantage over others in the species.

10.51 Recognize mutation (changes in DNA) and recombination as the sources of heritable variations that give individuals within a species survival and reproductive advantage or disadvantage over others in the species. Describe how a variety of influences may cause gene mutations. **Standard (s) 7.13, 7.31, 7.32, 7.43**

10.52 Conduct a natural selection simulation and use data generated from it to describe how environmentally favored traits
are perpetuated over generations while less favorable traits decrease in frequency. **Standard(s) 7.31, 7.32, 7.43**

10.53 Cite evidence (Darwin's finches, fossils, melanin in peppered moths, anatomical or biochemical comparisons) from a variety of extinct and present day species to support evolution and natural selection. Draw reasonable conclusions regarding evolutionary change over time. **Standard(s) 7.31, 7.32, 7.43**

10.54 Recognize that evolution involves changes in the genetic make-up of whole populations over time, not changes in the
genes of an individual organism. Distinguish between short term physiological adaptations in an organism (e.g., skin tanning and muscular development) and long term evolutionary changes in a population (e.g., cranial capacity and curvature of the spinal). **Standard(s) 7.31, 7.32, 7.43**

10.55 Trace the history and context of the development of the theory of natural selection. Use natural selection as an example to explain how science advances knowledge through careful observation, rigorous testing of hypotheses, and formation of theories. **Standard(s) 7.31, 7.32, 7.43**

Performance Indicators

Level Three
(Grade 11)

Newtons' Laws of Motion and Universal Gravitation

An understanding of forces allows scientists to explain and predict changes in the motion of an object including its velocity, acceleration, equilibrium, and momentum.

11.01 Conduct investigations using appropriate technologies to explain the relationship between distance, time, velocity and acceleration for an object in horizontal and vertical motion. **Standard(s) 3.22, 3.23**

11.02 Graph data collected in horizontal and vertical motion investigations and describe the relationship between the distance vs. time graphs, and the objects velocity and acceleration. **Standard(s) 3.22, 3.23**

11.03 Calculate the average velocity ($v=d/t$) and average acceleration $a=(v-v_0)/(t-t_0)$ of an object in motion. **Standard(s) 3.22**

11.04 Recognize that all objects exert attractive gravitational force on other objects, and that this mutual attraction between two masses explains how objects, the atmosphere, and the seas stay fixed to the surface of the earth. **Standard(s) 3.23, 4.21**

11.05 Use data gathered in previous motion investigations to describe the vertical motion of an object (with weight as the only force acting on the object) and demonstrate that the object rises and falls at a constant acceleration due to gravity. **Standard(s) 3.22, 3.23**

11.06 Use data gathered in previous motion investigations to demonstrate that vertical acceleration due to gravity is unaffected by constant horizontal motion of an object. Recognize that objects fall at the same rate independent of any initial horizontal velocity. **Standard(s) 3.22, 3.23**

11.07 Apply Newton's Law of Motion when investigating the effect of force on velocity, acceleration, and equilibrium of an object. Recognize that the tendency of an object to remain at rest or in motion is called inertia. To change the motion of an object with inertia, unbalanced forces must act on the object. **Standard(s) 3.23**

11.08 Conduct investigations to explain the relationship between the launching angle of an object in projectile motion and the horizontal and vertical distance traveled by the object. **Standard(s) 3.23**

11.09 Conduct investigations using appropriate technologies to explain the relationship between an object's mass and motion, and that object's momentum. Recognize that momentum is a measure

of the difficulty encountered in bringing an object to rest. The greater the object's mass and velocity, the greater is its momentum (P=mv). **Standard(s) 3.23**

11.10 Use data gathered in momentum investigations to demonstrate that the change in momentum of an object is dependent on the force acting on it and the time over which the force acts. Recognize that if an object is stopped very quickly the force involved is large, but if an object is stopped more slowly the force involved is smaller ($Ft=m(v-v_0)$). **Standard(s) 3.23**

11.11 Apply momentum concepts to practical situations such as collisions, seat belts, airbags, sports, and rocket motion. Use the Law of Conservation of Momentum to predict the outcomes of a collision between moving objects. **Standard(s) 3.23, 3.52**

Newton's Law of Universal Gravitation, which holds that all matter interacts via gravity, developed gradually over centuries. Tracing the development of this law demonstrates how scientific knowledge changes by evolving over time, almost always building on earlier knowledge.

11.12 Compare Aristotle's theories regarding Earth's position in the Solar System to those of Copernicus. Explain how Aristotle's gravitational theory, which was based on an Earth-centered view of the Solar System, was rendered implausible when Copernicus advanced his theory that the Sun was at the center of the Solar System. **Standard(s) 1.21, 1.22, 1.31**

11.13 Read accounts on the life of Copernicus and the theories he developed regarding gravity. Recognize that although Copernicus was correct in his belief that the Sun is at the center of the Solar System, his understanding of gravity (only similar matter interacts) was incomplete. **Standard(s) 1.21, 1.22, 1.31**

11.14 Examine Galileo's life and the theories he developed. Explain his theories regarding free falling bodies, and how the theories advanced scientific understanding of motion. Recognize that in spite of his expanded understanding of free falling bodies, he was still committed to the belief that only like substances attract. **Standard(s) 1.21, 1.22, 1.31**

11.15 Describe how Kepler's analysis of data acquired from earlier astronomers' observations led to his conclusion that the Earth, the Moon, the Sun, and the waters all interact gravitationally. Describe also how Kepler's observations led to his identification of patterns of movement of the planets around the Sun. Explain the extent to which the results of Kepler's investigations influenced theories developed by Newton. **Standard(s) 1.21, 1.22, 1.31**

11.16 Discuss the life and work of Newton. Recognize that Newton's Law of Universal Gravitation and Laws of Motion provided the theoretical basis for explaining Keplers' Laws of Planetary Motion. **Standard(s) 1.21, 1.22, 1.31**

11.17 Identify the cultural events, beliefs, and/or values that either hindered or helped promote acceptance of the Law of Universal Gravitation. Explain how cultural influences often determine societies' willingness to embrace and accept new scientific understandings. **Standard(s) 1.21, 1.22, 1.31**

Physical Laws that Operate in the Universe

Scientists assume that the Laws of Matter and Energy are the same in all parts of the Universe. Therefore, laws that have been formulated to describe how forces effect motion here on Earth, have been used to explain planetary motion and to make space exploration possible.

11.18 Use Newton's Law of Universal Gravitation to explain why the Moon exerts a smaller gravitational force on an object than the Earth would on that same object. Use the same law to also explain why an object weighs less in space than it does on Earth. **Standard(s) 3.23, 4.21**

11.19 Use tide tables and a lunar calendar as evidence to explain the mutual gravitational attraction between the Earth and the Moon. **Standard(s) 3.23, 4.21**

11.20 Observe the circular motion of a variety of objects such as a rubber stopper wheeling around on the end of a string, a coin resting on a rotating turntable, etc. Recognize that circular motion always requires a force pulling the moving object toward the center of the circle (centripetal force). Relate this phenomenon to a satellite orbiting Earth. **Standard(s) 3.23, 4.21**

11.21 Use results from previous projectile and vertical motion investigations to describe how it is possible to launch rockets into outer space and have them maintain their orbit. **Standard(s) 3.23, 4.21, 4.31**

11.22 Use the Law of Conservation of Momentum to explain how a spacecraft in orbit around the Earth moves out of orbit by firing its rocket motors. Recognize that when burned fuel is pushed out the back of the motor, the spacecraft moves forward and the total momentum of the spacecraft and gases is unchanged. **Standard(s) 3.23, 4.21, 4.31, 8.52**

11.23 Relate the results of projectile motion investigations to sports, such as, long jump, high jump, shot put, basketball, etc. Describe how the Laws of Motion that apply to the launching of rockets likewise apply in the world of sports. **Standard(s) 3.23**

Scientist's understanding of the Universe is based on observations and data, which are used to construct models and to develop and test theories of how the Universe has evolved.

11.24 Construct spatial models of the solar system to accurately convey the vastness of the Universe and the smallness of the human scale in relation to the cosmic scale. **Standard(s) 4.12**

11.25 Construct models of cosmic evolution, such as time-lines, walks through time, or cosmic calendars, to represent the enormous length of the cosmic time scale. **Standard(s) 4.12**

11.26 Research and describe at least one of the significant episodes of cosmic evolution (e.g.,, Big Bang, formation of the Sun and planets, and future life cycle of the sun). Identify several observations which demonstrate why our understanding of the episode has become secure scientific theory, and to explain the connection between theory and evidence. **Standard(s) 4.12**

11.27 Use any number of devices (e.g.,, models of the Earth and Sun, flashlights shining on graph paper, thermometers, observation of the sun in the real sky, and computer simulations) to demonstrate how the amount and distribution of energy that reaches the Earth from the Sun, determines seasonal and global climates. **Standard(s) 4.14**

11.28 Use library and internet resources to identify characteristics of the Earth which permit it to support life, and compare those characteristics to properties of other planets. Based on the research, debate the possibility of life on other planets. **Standard(s) 4.13**

Electric Force

Electric force is a universal force that exists between any two charged objects and binds matter in all of its observable forms.

11.29 Conduct electrostatic investigations (e.g.,, rubbing a glass rod against silk, rubbing a balloon and sticking it on the wall) to demonstrate the extent to which different objects will attract other objects. Explain how in these cases when two objects are put in contact, one of them looses electrons becoming positively charged, while the other gains electrons becoming negatively charged. **Standard(s) 3.13**

11.30 Use visual representations to trace the movement of the electrons between negatively or positively charged objects and neutral objects. **Standard(s) 3.13**

11.31 Recognize that objects of like charge repel each other, while objects of opposite charge attract each other. The attractive and repelling forces between the objects is the electrical force. **Standard(s) 3.13**

11.32 Use a Van de Graaf generator to demonstrate the build up of static charges and the visible discharge of electrons from one area to another. Relate the results of the demonstration to the phenomenon of cloud to ground lightning. **Standard(s) 3.13**

11.33 Use appropriate technology (e.g., ammeters, voltmeters) to verify the relationship between electric current, voltage, and resistance. Recognize the electric current flowing in any circuit or part of a circuit depends on the voltage and resistance and can be calculated using Ohm's Law. **Standard(s) 3.12**

11.34 Conduct investigations to determine the extent to which various factors such as material composition, dimensions of the material (e.g., length, width, diameter) and temperature effect electrical resistance. **Standard(s) 3.12, 3.13**

11.35 Apply Ohm's Law to series, parallel, and combination circuits to determine the relationship between current, voltage, and resistance. **Standard(s) 3.12**

11.36 Recognize that an electric current in a wire has a detectable magnetic field and that electricity and magnetism are two aspects of a single electromagnetic force. **Standard(s) 3.14**

11.37 Conduct investigations to demonstrate and to explain that moving electric charges (in a current carrying wire) produce magnetic forces and that moving magnets produce electric forces. Relate the results of the electromagnetic force investigations to explain how electric motors and generators work. **Standard(s) 3.14**

11.38 Research how local electric power stations use electric and magnetic forces to generate electricity.
Standard(s) 3.51, 3.52

The Dynamic Earth

The outward transfer of Earth's internal heat drives the movement of large rigid tectonic plates. Plotting the occurrence of earthquakes and volcanoes provides evidence that the plates are moving and supports the Theory of Plate Tectonics.

11.39 Use models or computer simulations to demonstrate what occurs when two landmasses move towards each other. Describe how the properties of the sediments and the movement of the masses can result in folds or faults.
Standard(s) 5.21, 5.22

11.40 Use geological cross sections and three dimensional models to demonstrate how relative dating techniques can be used to determine geological events and the age of folded or faulted land forms. **Standard(s) 5.21, 5.22**

11.41 Observe computer or video simulations to describe what occurs when two landmasses or tectonic plates separate. Explain why scientists now believe that the creation of ocean crust along the mid-ocean ridge is related to plate separation. **Standard(s) 5.21, 5.22**

11.42 Recognize that the theory of plate tectonics supports the scientific belief that rigid plates move over the Earth's
Surface, and that earthquakes, volcanoes, and mountain ranges occur at plate boundaries.
Standard(s) 5.21, 5.22

11.43 Use the internet, library, or other databases to compile a list of earthquakes or volcanoes which have occurred over a given period of time. Determine the location of these occurrences (by latitude and longitude) on a map or globe, and identify any patterns in the occurrence of volcanoes and earthquakes. **Standard(s) 5.21, 5.22**

11.44 Describe how patterns identified in the previous plotting activity supports the theory of plate tectonics.

Standard(s) 5.21, 5.22

11.45 Recognize that the movement of continents occurs because they are part of rigid tectonic plates that move and that the energy required to move these plates comes from Earth's internal heat. **Standard(s) 5.21, 5.22**

During the last century, scientists theorized that the Earth was composed of a single giant continent, Pangea, which began to break up 200 million years ago into the continents as we know them today. Although scientists spent many years debating the validity of the theory, eventually structural geophysical and pale ontological evidence would be used to support the Theory of Plate Tectonics which provided an explanation as to how the continents separated.

11.46 Work collaboratively within a group to research how specific pieces of evidence support the Theory of Plate Tectonics. Selection of evidence to be researched could include the following:

- palm tree fossils found in Greenland;
- remarkable similarity of rocks, geologic structures and fossils on opposite sides of the Atlantic Ocean;
- fossils of the late Paleozoic reptiles Mesosaurus found in eastern South America and western Africa and nowhere else in the world;
- evolution of vertebrates and land plants showed similarities in development in different continents up to the supposed break up time, but then divergent evolutionary paths;
- distribution of Permian glaciers and deposit of "Moraine" in South America, Africa, Australia, India;
- marsupial mammals found in Australia and South America;
- deep sea sediments containing fossils found on land;
- newer rocks and sediments found at the mid-ocean;
- magnetic reversals found in rocks in the Atlantic Ocean floor. **Standard(s) 5.21, 5.22**

11.47 Describe how an accumulation of evidence was required before scientists were willing to accept the Theory of Plate Tectonics. **Standard(s) 1.31**

11.48 Explain how the Theory of Plate Tectonics demonstrates that scientific knowledge changes by evolving over time. Recognize that although some theories are initially rejected, they may be re-examined and eventually accepted in the face of new evidence. **Standard(s) 5.21, 5.22**

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